A Web Based Collaborative Design Environment For Spacecraft

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ABSTRACT

In this era of shrinking federal budgets in the USA we need to dramatically improve our efficiency in the spacecraft engineering design process. We have come up with a method which captures much of the experts' expertise in a dataflow design graph

- Seamlessly connectable set of local and remote design tools
- Seamlessly connectable web based design tools
- Web browser interface to the developing spacecraft design

We have recently completed our first web browser interface and demonstrated its utility in the design of an aeroshell using design tools located at web sites at three NASA facilities. Multiple design engineers and managers are now able to interrogate the design engine simultaneously and find out what the design looks like at any point in the design cycle, what its parameters are, and how it reacts to adverse space environments.

1.0 OVERVIEW

Our system, the Integrated Synthetic Design Environment (ISDE) is a family of tools for the design, analysis and simulation of spacecraft and their components. The family is designed to run distributed across all of NASA and, perhaps in future, outside NASA contractors. The ISDE integrates the design tools at the various sites and allows for their inter-use by other facilities while remaining under the control of the originating site. Data is seemlessly passed back and forth between the sites and transformed whenever necessary. An important goal of the ISDE is to preserve legacy codes by wrapping them to fit with the distributed data flow.

We presented a paper on the ISDE some years ago at this conference and now wish to report on some new work to do with using tools resident on the world wide web and also to present a new user interface accessible from the world wide web. The two are orthogonal in the sense that the web based tools can be used with a native user interface and vice versa.

2.0 DESIGN OF THE ISDE

The ISDE enables integration of functional-requirements models with physics-based models (e.g., of instruments and real-world phenomena [2-7]), in order to allow interactive design based on observation of spacecraft performance in a simulated mission context.

The central component of the ISDE is a Programmable Tool Server (the Millennia Engine), which enables these models and tools to be interconnected. This allows distributed real-time simulation to be performed at various levels of fidelity under user control. The environment allows commercial tools to be used as well as experimental or "home-grown" tools (such as probabilistic analysis methods).

The developers and early users of the ISDE are thus benchmarking existing tools for inclusion in the new process as it emerges, and can hence provide clearer definition (e.g., to commercial suppliers) of enhancements which would be required to make development of next-millennium spacecraft progressively more seamless and adaptable.

2.1 Components of the ISDE

The components of the ISDE are pictured schematically in Figure 1, which also shows current participation of various NASA centers and vendors.

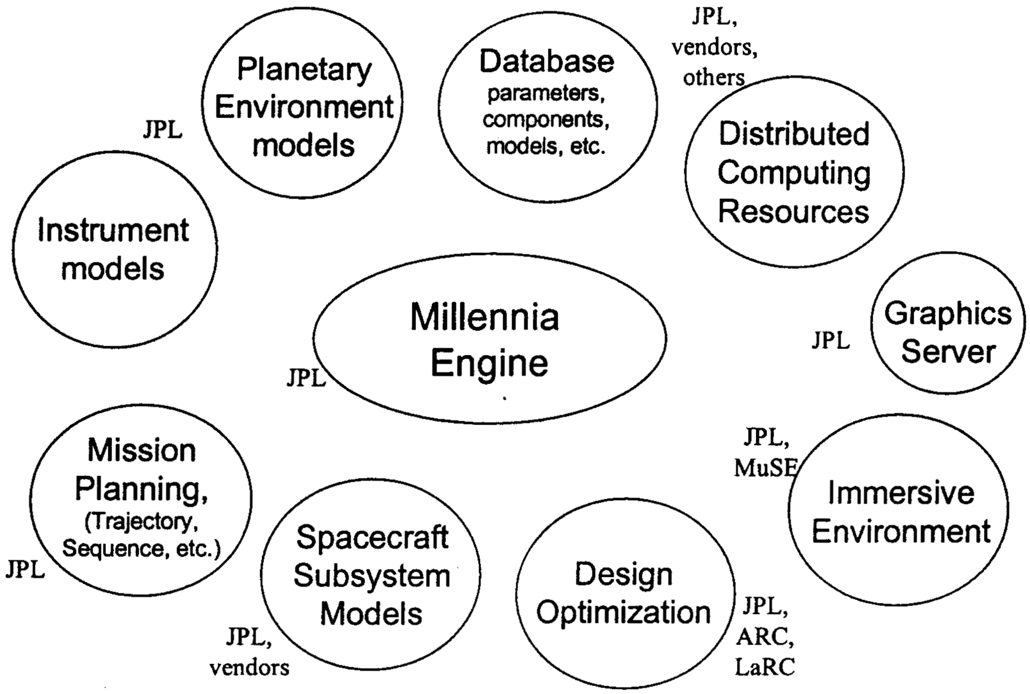

Figure 1: Schematic Representation of Immersive Synthetic Design Environment (ISDE) Components

2.2 MIDAS and the Millennia Engine

The Millennia Engine provides an infrastructure to integrate design and analysis tools and present the user with a "plug-and-play" interface that allows many of the above integrated design goals to be met. It can provide access to a database of components, analysis tools, visualization tools, drawings, and documents. A designer can develop a reproducible design methodology by first connecting these resources together and then performing interactive exploration of the operation of the designed object in appropriate context (i.e., seamlessly moving back and forth between simulation and design). The methodology is generated and modified graphically (*methogram*), and can be used to capture of the customary process followed by a particular designer for making decisions about the form and attributes of each component. The methogram is saved in the database and can thus be reused either in another part of the design or adapted for a later design.

A CORBA based central server, the Millennia Engine, allows capture of a key designer's expertise in a dataflow design graph. This is not a "knowledge-based" approach in the usual sense, but is rather a prescriptive representation of the methodology that an expert would use in designing some aspect of the spacecraft. The *methogram* is then usable by a generalist who is then able to perform more integrated conceptual design and trades with a very small team, thus providing the potential to improve the early design process as mentioned above.

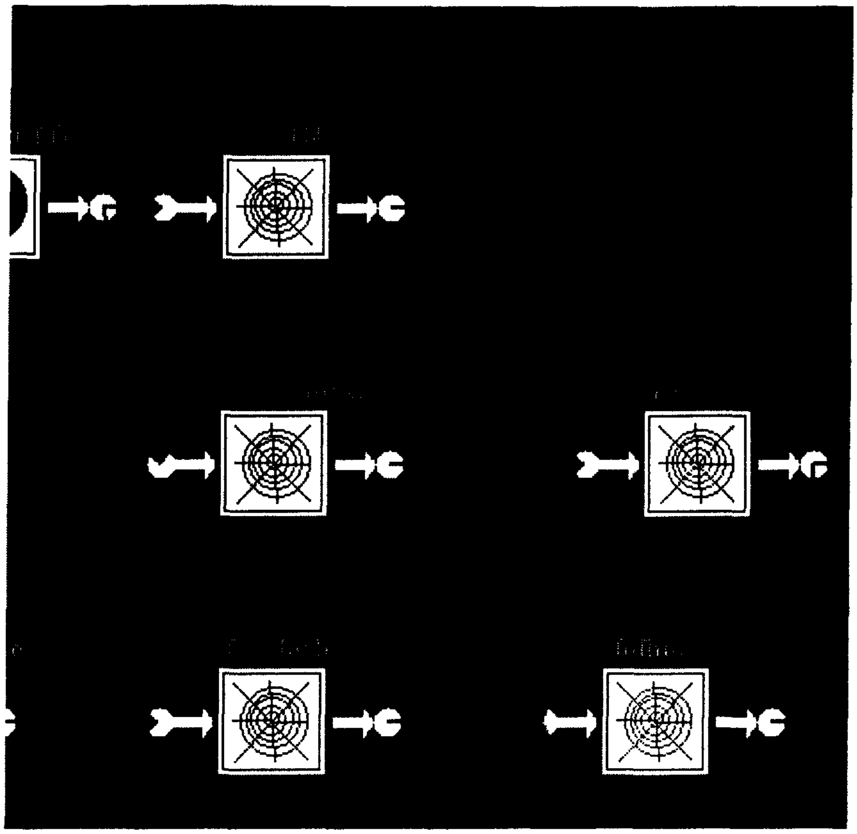

Figure 2: Piece of a methogram showing data flow between web based tools

We have completed the first phase of our effort to make design and analysis tools more accessible and collaborative. Capture of the design process in an electronic form also paves the way for computer-aided optimization, allowing vastly greater search of the possible design space and interaction with the requirements. An almost arbitrarily complex set of methograms can be executed on a network of workstations, including supercomputers at JPL or other collaborators' facilities.

3.0 ISDE AND THE WORLD WIDE WEB

3.1 Web Accessible Tools

Normally the engine starts up and passes data to tools on other platforms via remote procedure calls (RPCs) or by the use of a slightly higher-level cross-platform interconnection methodology called Parallel Virtual Machine (PVM). These protocols are usually only available on "friendly" computers, normally those co-located with the Millennia Engine platform.

These days, because of the enormous web activity, many tools are becoming available at "unfriendly" sites that do not allow direct access (e.g., via RPCs or PVM) because of security concerns. These sites typically allow their tools to be used in a structured way, e.g., by setting up web forms for data input, and displaying the tool results by dynamically creating a new web page, VRML file, or similar viewable products. We recognized that the Millennia Engine could be much enhanced if it were able to communicate with such sites. The possibilities opened up by this enhancement include being able to pass data generated by web-based tools to those on local machines and back again. We have actually constructed a methogram for NASA's Ames Research Center (ARC) with over a dozen distributed web tools all chained together in this way.

Addition of this "web tool" feature to the Millennia Engine (Version 6.0) was quite difficult. Coincidentally, the World Wide Web Consortium (W3C) was just releasing a C++ library package to allow communication with a web site from a C++ program emulating a user interaction. However, our first few attempts at using this library showed up several important bugs that the W3C acknowledged and took care of very efficiently. Eventually we achieved success. We decided to make the web communication process a separate CORBA server (web_agent) so that other projects could use it without having to integrate it directly into their code.

3.2 Web Accessible User Interface

Our original graphic user interface was Methedit, a C++/X11 tool which could attach itself to the millennia engine by using a CORBA link. While keeping alive the distributed nature of the ISDE, this design suffered from the fact that each user would need to have a copy of Methedit on their machine.

The methogram editor tool, netMethedit, is a rewrite of Methedit in Java. Since Methedit communicates with the Millennia Engine using CORBA, it was also necessary to add Java classes that can perform the same function. Fortunately, a new Java/CORBA package became available in 1996 called OrbixWeb (IONA Technologies). A great effort was made to keep the look and feel of Methedit in the new product. The maturity of the Java AWT package presently offers all the features available in the older X-windows package used by the original Methedit and we were able to keep most of the interface identical. One area where we had problems was in terms of design security. In a non-browser client (e.g., via Xterm), the Millennia Engine can determine who is connected by asking the operating system to give information about the login. This is not possible with "anonymous" browser access so we plan to add extra username/password protection in a future release.

We made our first release of netMethedit in September 1998 and NASA-ARC is our first user. The JPL/ARC/LaRC aeroshell design collaboration is described further below.

4.0 APPLICATIONS TO DATE

NASA-ARC provided us with a challenge to try using several web sites at LaRC, JPL, and ARC for the collaborative design of aeroshells. This involves aerodyamic (LaRC) and thermal protection (ARC) for situations such as robot landers on Mars. The methogram we constructed will be made available to all NASA sites through netMethedit (see Section 4.2 below) and perhaps netISDE (see Section 4.3 below). Through the use of netMethedit, it will be possible to edit the methogram to substitute other web site tools or tools on local machine.

5.0 REFERENCES

[1] J.S. Jenkins et al., "Enterprise Information System Architecture Document", JPL internal D12991, Dec. 1996

[2] M. Lee, R. Swartz, A. Teng, and R. Weidner, "Encounter Geometry and Size Data Gathering Simulation", Proc. AIAA Conf. On Guidance and Control, Aug. 1997.

[3] A.K. Noor, S.L. Venneri, J.M. Housner, and J. Peterson, "A Virtual Environment for Intelligent Design", Aerospace America, April 1997 pp 28-35.

[4] Fukunaga A, Chien S, Mutz D, Sherwood R, Stechert A. "Automating the Process of Optimization in Spacecraft Design", Proc. IEEE Aerospace Conf., Snowmass CO, Feb. 1997.

[5] Fukunaga A, "Application of an Incremental Evolution Technique to Spacecraft Design Optimization", Proc. IEEE Int. Conf. on Evolutionary Computation, April, 1997.

[6] Fukunaga A, Stechert A. An Evolutionary Optimization System for Spacecraft Design. Proceedings of Tenth International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems, June, 1997.

[7] Fukunaga A, Stechert A., "Towards a Self-configuring Optimization System for Spacecraft Design", Proc. Int. Symp. on Artificial Intelligence, Robotics and Automation in Space, July, 1997.

[8] Norman Lamarra and Julia Dunphy, "Interactive Sharable Design Environment Integrating Spacecraft Design and Mission Modeling", AES Conference, February 1998

[9] Julia Dunphy , John C. Peterson and Jose J. Salcedo, " Integrated Synthetic Design System-Designing Spacecraft In Virtual Reality", IDMS Conference, Berlin, Germany March 1996